Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Summary of ETRI NB PHY proposal]
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Abstract: This contribution is prepared to summarize the ETRI NB PHY for LECIM networks

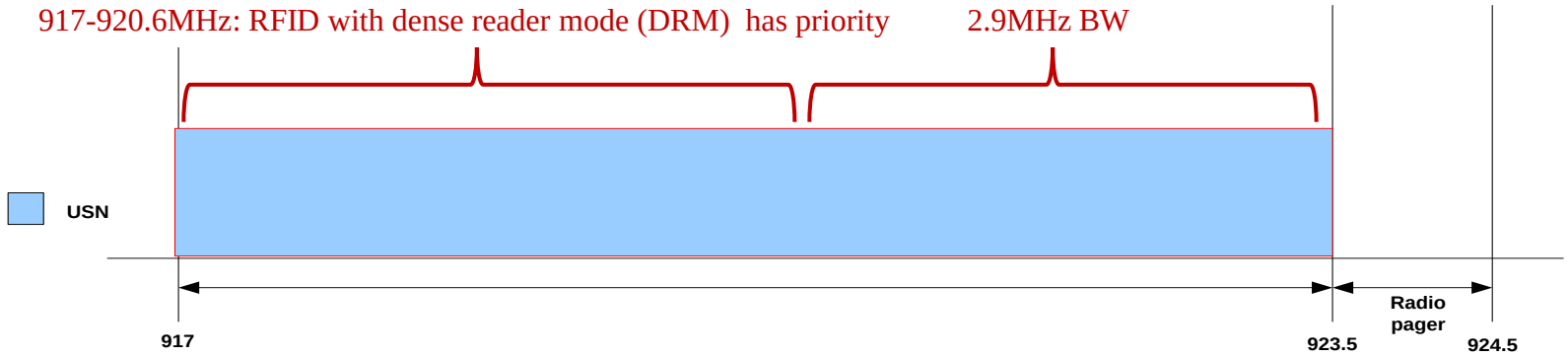
Purpose:

Contents

- Motivation of NB FSK PHY
- Proposed NB FSK PHY
- Packet format
- Preamble and SFD
- PHR & PSDU
- P-FSK Modulation
- Data rate
- Key aspects of PHY proposal

Motivation of NB FSK PHY (1)

- 900MHz channel plan for USN in Korea (doc. 15-10-0335)



  - RFID and USN devices can use this band.
  - RFID with DRM has priority in 917-920.6MHz band.
  - Max. EIRP: 10dBm

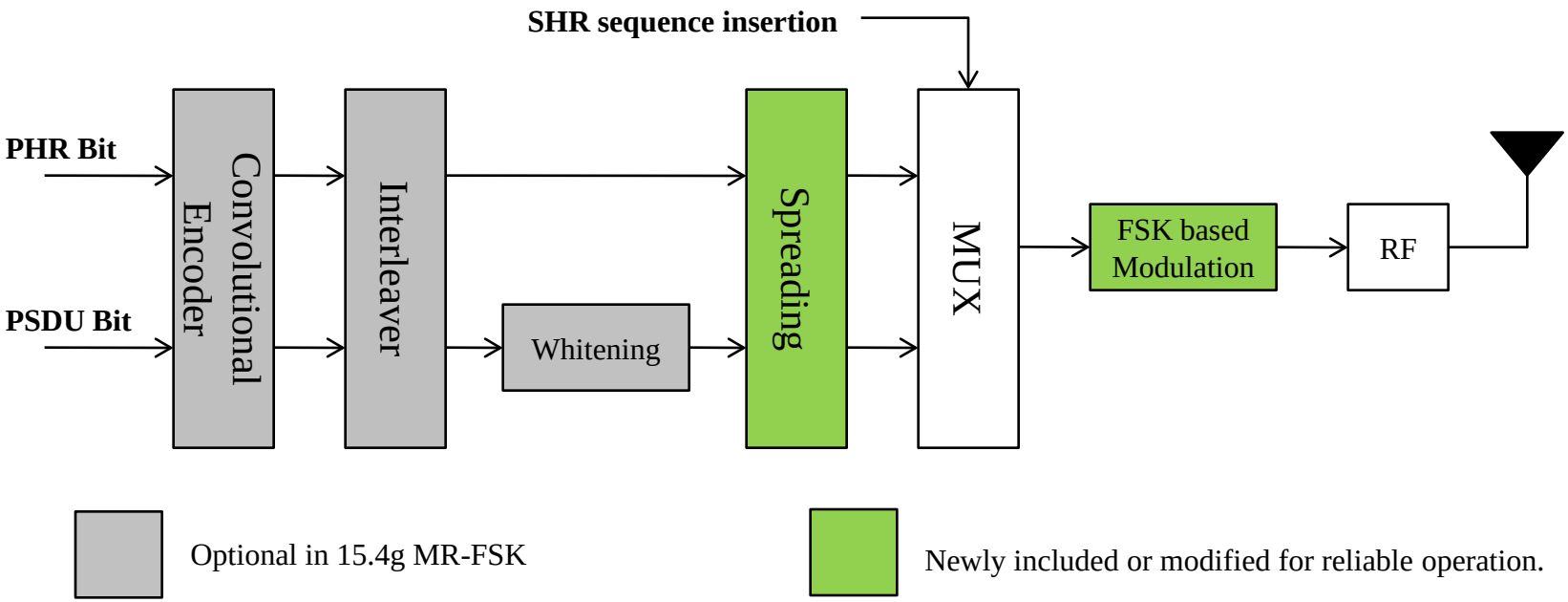
- It is hard to allocate the wideband PHY in Korea USN band and the NB PHY would be adequate for this band.

Motivation of NB FSK PHY (2)

- Benefits of Narrowband FSK PHY
  - Lower the noise level
  - No need of high-linearity power amplifier (PA)
  - Non-coherent receiver: low-power consumption
    - No need to track the phase of the carrier
    - Performance difference between coherent receiver and non-coherent receiver: roughly 1dB
    - Suitable for battery-powered endpoint devices
  - Simple, cheap and proven technology

Proposed NB FSK PHY (1)

- System block diagram
  - Basically, the architecture is same as 15.4g MR-FSK.
  - The colored blocks are required for reliable operation in harsh LECIM environments

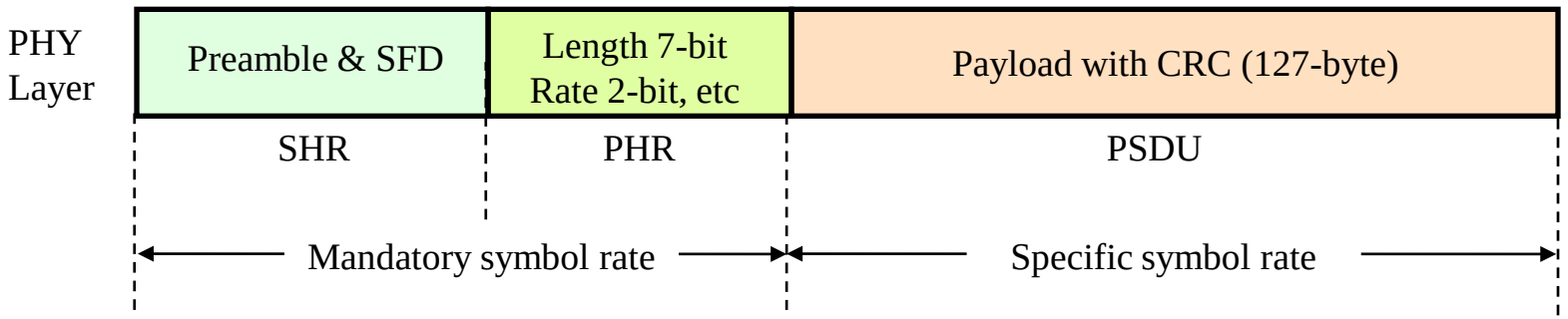


Proposed NB FSK PHY (2)

- Functional blocks for reliable operation
  - Regulation issue
    - With the low EIRP (e.g., 10dBm in Korea 900MHz band), it is hard to satisfy the link budget
    - Considering 900MHz large urban channel, the RX power is calculated as -118.4dBm@10dBm EIRP
  - Harsh LECIM channel environments

Packet Format

- PHY packet format



  - SHR & PHR: transmitted at mandatory data rate
  - PSDU: transmitted at data rate specified in PHR

Preamble & SFD

- Long preamble and SFD sequence are necessary due to harsh and high path loss channel environment
- Preamble
  - Multiples of “01010101”
  - Fixed number of preambles is desirable
- SFD
  - Repetition of 15.4g SFD sequence
  - 15.4g SFD sequence: 16-bit
  - Benefit
    - SFD detector can use full SFD sequence or part of SFD sequence according to its capability and channel condition

PHR

- PHR sequence

Octets: 1				1	
Bits: 1	2	3	2	1	7
OP	IDepth	SF	Rate	EXT	Length
PHR					

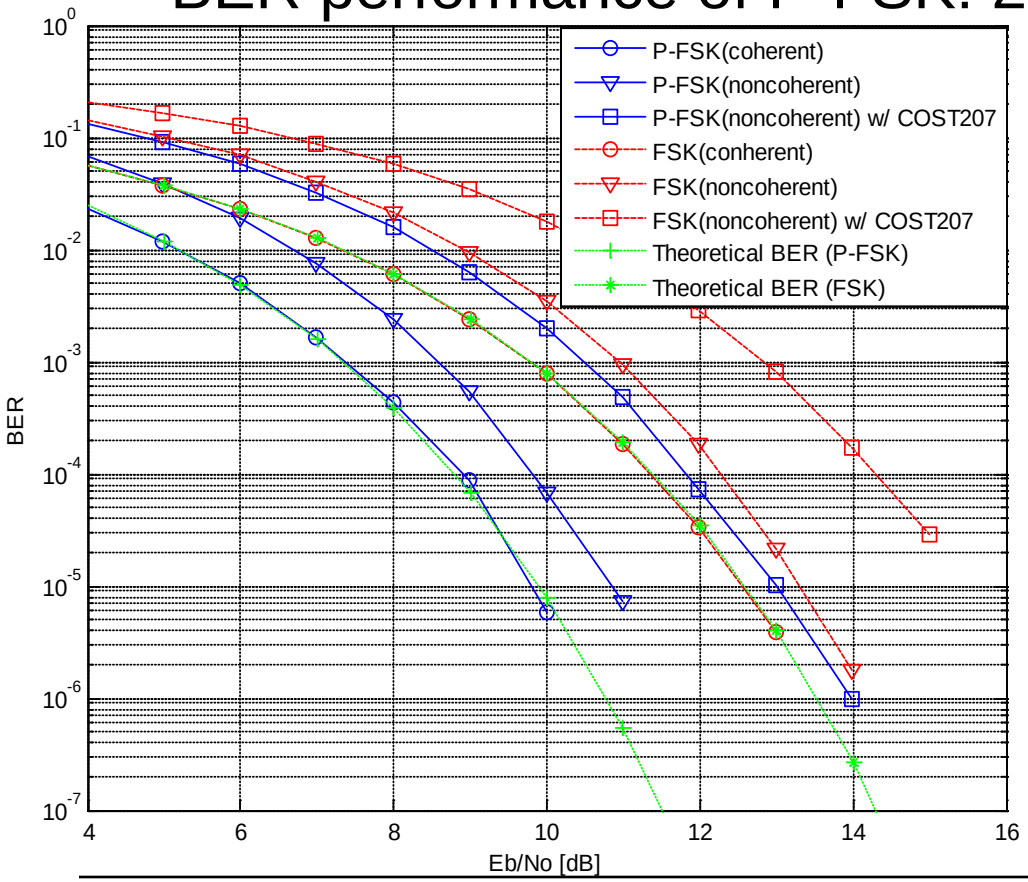
  - Length: 7-bit → max. PSDU 127-octet
  - Rate: 2-bit → Data rate
  - Spreading factor (SF): 3-bit
  - Interleaving depth (IDepth): 2-bit
  - Odd parity (OP): 1-bit
    - Simply detect PHR error to stop demodulation process

PHR & PSDU

- PHR and PSDU are encoded by rate ½ convolutional code with interleaving
  - Different interleaving depth for considering channel coherence time
- Data whitening for PSDU: Same as 15.4g
- Spreading: Simple repetition scheme
  - SF: 1(0dB), 2(3dB), 4(6dB), 8(9dB),16(12dB), 32(15dB)
  - SF can be selected according to regulation and channel condition
    - The large SF (16 or 32) will generate a packet with long duration. It should be avoided in certain regulatory domain.

Position-based FSK (P-FSK) Modulation

- P-FSK: 4-dimension orthogonal signaling
- BER performance of P-FSK: 2.7dB gain at BER 10^{-5}



- Mains powered coordinator
  : recommend the coherent receiver
  : performance enhancement

- Battery powered endpoint
  : recommend the non-coherent receiver
  : low power consumption

-Non-coherent receiver for P-FSK
  : same as the conventional FSK
  : computational overhead is negligible

- Multipath channel model
  : COST 207 for 900MHz band

Data Rate

- Asymmetric data flow between uplink and downlink
  - More data from endpoint device to coordinator
- Data rate: 40Kbps (UL), 20Kbps(DL)
- Data rate depends on coding rate and spreading factor

< Data Rate Table >

SF	UL	DL
1	40 Kbps	20 Kbps
2	20 Kbps	10 Kbps
4	10 Kbps	5 Kbps
8	5 Kbps	2.5 Kbps
16	2.5 Kbps	1.25 Kbps
32	1.25Kbps	0.625 Kbps

Key Aspects of PHY Proposal (1/2)

Parameter	Proposed narrowband PHY
Operating band	Same as 15.4g
Modulation	FSK-based orthogonal signaling
Symbol rate	40Kbps (uplink), 20 kbps (downlink)
Spreading	Spreading factor: 1, 2, 4, 8,16, 32
FEC	Convolutional code with interleaving
Data whitening	Same as 15.4g
PHY frame structure:	
- SHR	Multiples of “01010101” + 64 bit SFD
- PHY header	16-bit including length 7-bit, rate 2-bit, spreading factor 3-bit, interleaving depth 2-bit, odd parity 1-bit
- Max. PSDU	127-octet
- CRC	Same as 15.4g

Key Aspects of PHY Proposal (2/2)

Parameter	Proposed narrowband PHY
Channel spacing	Same as 15.4g
Transmit Power	As allowed by regulatory regimes
PSD	As allowed by regulatory regimes
Link Quality Indication	RSSI
Co-located networks features	Channel diversity
Co-existence features	Channel diversity
Power efficiency features	FSK-based modulation, parity in PHR, low-power consumption endpoint device
Reliability enhancing features	FEC, whitening, spreading, long preamble & SFD sequence, etc